Airflow measurements at supply air terminal devices on residential balanced ventilation systems

Anne-Marie Bernard*[1], Valérie Leprince[2]

1 ALLIE'AIR
4 Clos Ballet
01800 Meximieux, France
** annemarie.bernard@allieair.fr*

2 PLEIAQ
84 C Av de la liberation
69330 Meyzieu

ABSTRACT

In France, the control of ventilation system at commissioning is mandatory in the context of the Effinergie + label and the measurement of airflows in residential houses is mandatory since 2017 in this label. The Promevent project (2013-2016) was aiming at improving the reliability of those controls. Guidelines have been issued for visual inspection of system, airflow measurements at air terminal devices (ATD) and ductwork airtightness measurements.

However, pending issues remained to measure airflow at supply ATD of balanced systems. This article deals with new tests performed at supply ATD.

Tests were made in laboratory (calibration like) and on site. Different anemometer hoods (single point hot wire, hot wire grids, propeller, powered hood...) were used.

Those tests have shown that :

- measures at supply are less reliable when ATD has uni-directional jet.
- the most suitable hood depends on its technology as well as its ability to measure small airflows.
- the ductwork accessories prior to the ATD also have an impact on results.

Resulting uncertainty is given as well as recommendations for measurements on site.

KEYWORDS

Airflow rate, measure, take-over, supply

1 INTRODUCTION

In France, the control of ventilation system at commissioning is mandatory in the context of the Effinergie + label and the measurement of airflows in residential buildings is mandatory since 2017 in this label. The Promevent project (2013-2016) was aiming at improving the reliability of those controls. First results of Promevent study had pointed out difficulties on some specific jets. As guidelines had to be issued for airflow measurements at ATD, additional tests were needed to better estimate uncertainty when measuring supply airflow. This additional study aim at determining the reliability of measurement at supply air terminal devices (ATD) and with small airflows rate (commonly found in residential balanced systems).

2 METHOD

For airflow measurements, we have used anemometers and hoods described in Table 1.

These devices have been tested :

- On a real installation : they have been compared to the fan airflow (calibrated measurement) after correction of ductwork air-tightness. This installation is used for training courses, with different type of semi-rigid ducts (oval, circular), sizes (80mm and 125mm diameter) and ATD connections (Figure 1). All ATDs connection have an elbow as standard ceiling installation. One of the ATD is supplied by 2 inlet duct (diameter 125mm). The ATDs used are described in Table 2.
- In laboratory as for calibration but with different ATDs compared to none
- In laboratory with prior airflow conditions (elbow, restriction…).

Table 1- Anemometers used for this study

Reference	**Photo**	**Type**	**Fabricant uncertainty**
KIMO DBM 200 (2 units)		Hot wire grill	0.. 300 m3/h ± 2% measured value or ± 2 m3/h
FLOW FINDER MK2		Several pressure measurement points. Powered flow hoods use a built in fan to compensate for the pressure drop caused by the capture hood itself. The transparent part can be removed.	10..550 m3/h ± 3% measured value or ± 3 m3/h
WOHLER FA 410		Propeller with 2 hoods	Not given with hood (propeller alone only)
TESTO 417 with flow straightener		Propeller with 2 hoods and additional flow straightener for supply jets and swirling …	7.. 500 m3/h ± 1.5% measured value or ± 2.5 m3/h

Table 2 - ATDs tested

ATD	**Photo**	**Type**	**Diameter (mm)**
ANJOS TESA/TMP		Fixed grill	80
ALDES BIO		Supply ATD with orientable flow, tested in 2 configurations vertical and lateral	80

LINDAB AIRY		ATD with radial flow (lateral)	125
ANJOS BOREA		Adjustable supply ATD	125
UBBINK		ATD with central cone	125

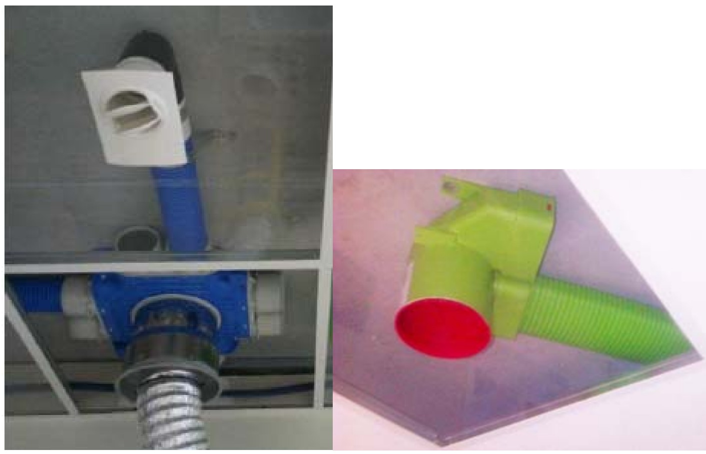

Figure 1 – On-site ATD installation (D80 duct left and D125 right)

3 RESULTS ON AIRFLOW MEASUREMENTS

3.1 On-site measurements

Results of on-site measurements are shown in Table 3 without any correction for calibration because this correction doesn't seem to improve the results.
The reference airflow at ATD is determined from the measurement at fan (calibrated on a test rig) minus a correction for ductwork airtightness (measured prior to these tests). For each ATD, 4 measurements at 15, 30, 45 and 90 m3/h are made and the maximum difference is reported for this ATD.

Table 3 : results obtained on-site measurement

		Diameter 125				**Diameter 80**			**Average Difference %**
		Ubbink	BOREA	AIRY	TMP	TESA	Bio (vertical)	Bio (lateral flow)	
Hot wire grill	KIMO DBM 1	15%	17%	10%	-6%	-7%	14%	-18%	12%
	KIMO DBM 2	20%	14%	16%	-3%	3%	22%	-18%	14%
Propeller	Wohler small hood	-19%	-21%	n.t	n.t	4%	-4%	19%	14%

	Wohler large hood	-10%	-9%	-4%	9%	1%	2%	-11%	7%
Pressure & fan assistance	Flow Finder 1	20%	27%	25%	17%	-6%	-5%	-6%	15%
	Flow Finder 2	16%	29%	25%	9%	10%	-10%	-15%	16%
Propeller	Testo small hood without straightener	-2%	-13%	0%	0%	13%	11%	35%	15%
	Testo small hood with straightener	28%	23%	0%	0%	0%	-7%	-23%	16%
	Testo large hood without straightener	7%	5%	19%	35%	5%	-1%	-12%	12%
	Testo large hood without straightener	24%	19%	27%	23%	-5%	-11%	-26%	19%
	Min difference	2%	5%	4%	3%	0%	1%	6%	7%
	Max difference	28%	29%	27%	35%	13%	22%	35%	19%
	Average difference	16%	18%	12%	10%	7%	13%	18%	14%
	Average for propeller	15%	15%	8%	11%	5%	6%	21%	14%
	Average for hot wire grill	17%	15%	13%	4%	5%	18%	18%	13%
	Average for fan assistance	18%	28%	25%	13%	8%	8%	11%	16%

n.t = not tested (hood too small for this ATD)

Maximum differences on airflow measured can vary from 0 to 35% depending on anemometer used and ATD type.
In average for all ATDs tested, differences vary from 7 to 19% and are quite similar for the 3 types of anemometers tested here.

3.2 Lab measurements with ATD results

Tests in lab have been done :

- In exhaust, without ATD, as for standard calibration
- In supply, without ATD, as for standard calibration
- In supply, withTMP ATD installed, to compare with on-site measurement
- In supply, with BOREA ATD installed, to compare with on-site measurement too

The pressure drop have been measured on the rig and expressed by coefficient K with

$$\Delta P = K.q^2 \quad (1)$$

with P static pressure in Pa et q airflow in m3/h

Figure 2 : measurement on the lab test rig

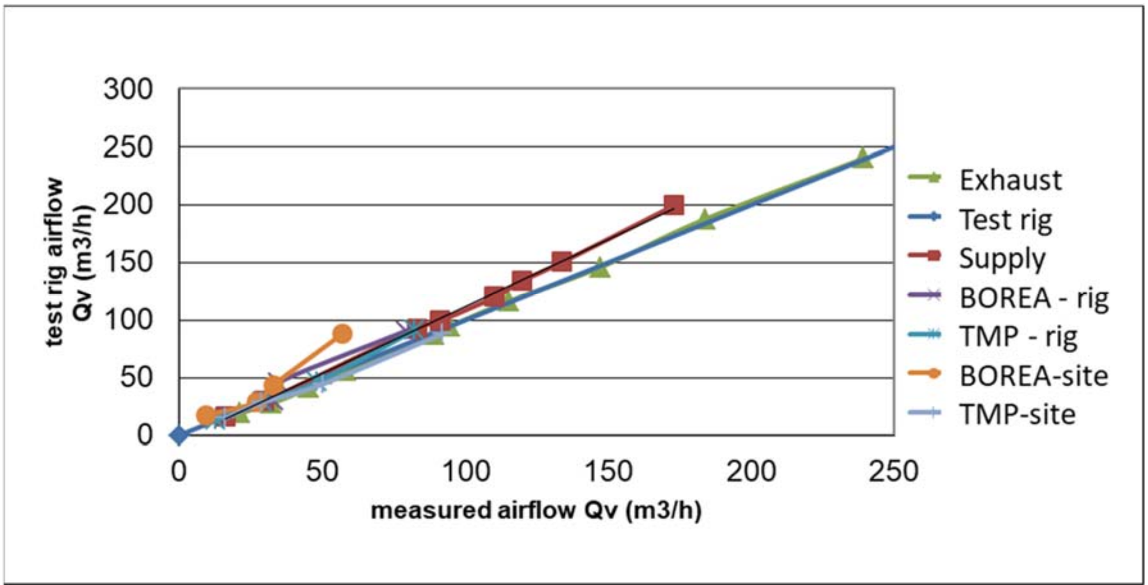

Figure 3 – exemple of results on a propeller hood

For propeller hood, the following general conclusion can be drawn:

- There is a low influence of the type of ATD on the results and calibration coefficients obtained without ATD seem to be applicable, calibration coefficients at exhaust or supply are similar.
- The pressure drop of these anemometers is high but still acceptable for the small airflows of individual houses (<2 Pa at 30 m3/h)

For hot wire grill anemoters we have noted that:

- Large differences are observed on the test rig between with and without ATD and also between each type of ATD.

- With ATD, there are large differences between on-site measurement and lab measurement. The ATD BOREA with higher pressure drop than the TMP one has the largestdifference between lab measurements and on-site measurement.

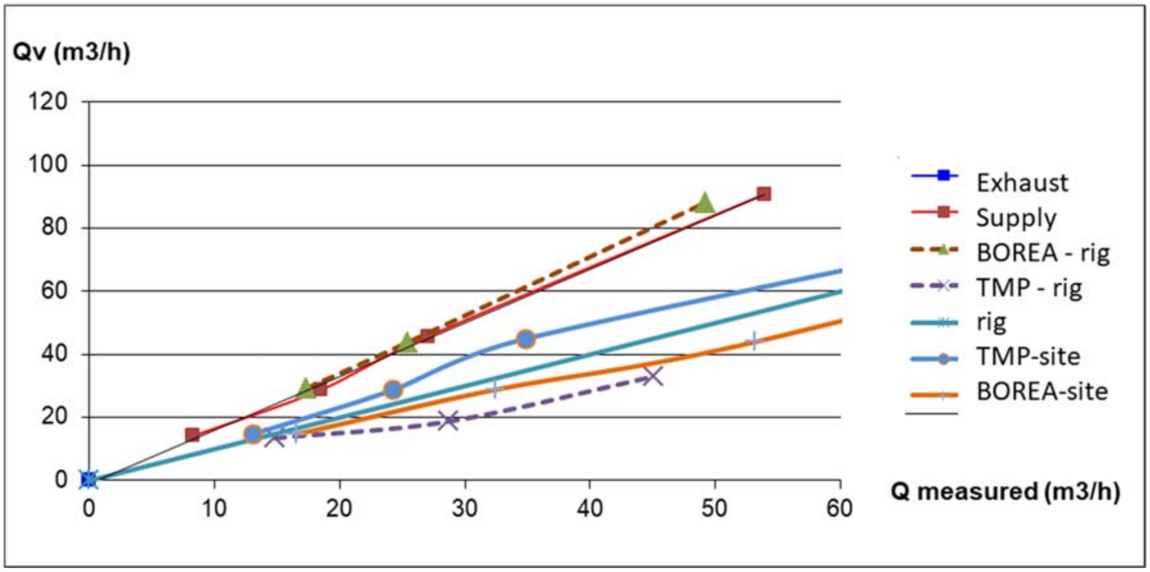

Figure 4 - exemple of lab results on a hot wire grill anemometer

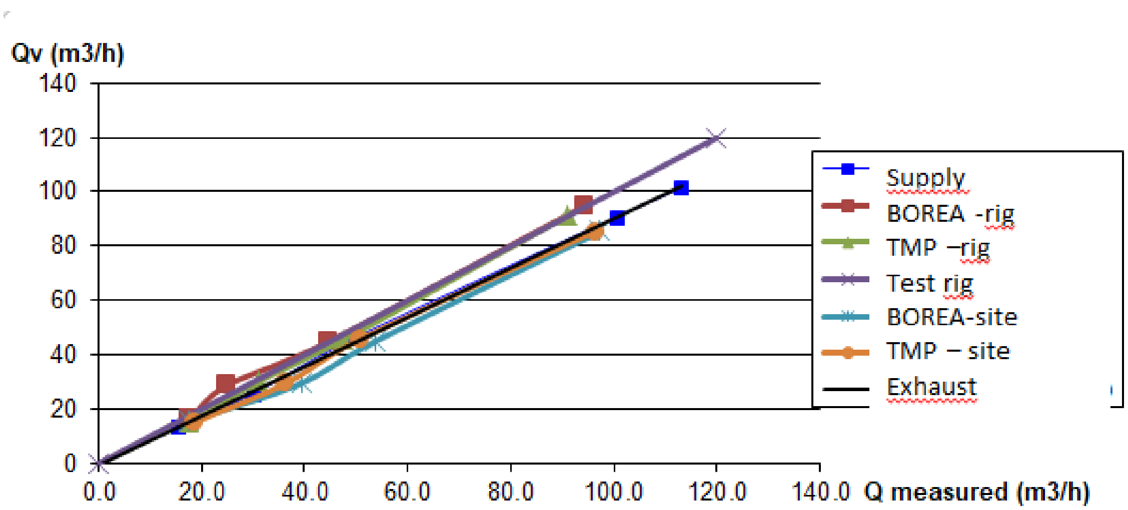

Figure 5 - exemple of lab-results on hood with a powered flow hood

The powered flow hood shows a good consistencyin labmeasurements.

All results are summarised in table 5

Table 4 - results of lab tests

Type	Hot wire grill		Powered hood		Propeller				
	DBM 200 2	DBM 200 1	FLOW FINDER (long hood)	FLOW FINDER (short hood)	Testo large hood	Testo 417 large hood + straightener	Testo 417 small hood	Testo 417 small hood+straightener	WOHLER FA410 large hood
Impact of TMP on lab test (with/without)	High	Very high	Low	Low	Very low	Very low	nc	Very low	low
Impact of BOREA on lab test (with/without)	Low	Low	Low	Low	Low	Very low	Very low	Very low	low
Impact of TMP on-site/lab	not measured	**High**	Low	Low	Very low	Very low	nc	Very low	Very low
Impact of BOREA on site/lab	**Very high**	**Very high**	Low	Low	**High**	Very low	low	Very low	low up to 50 m3/h
Difference supply/exhaust on lab calibration	18%	16%	not measured	not measured	22%	13%	10%	13%	10%
Difference supply/ test rig measure	**NA**	**NA**	17%	9%	17%	21%	13%	21%	13%
Difference exhaust/test rig measure	**NA**	**NA**	not measured	not measured	31%	29%	29%	29%	17%
Pressure drop coefficient K ($K=DP/Q^2$)	0.0005	0.000	not measured	not measured	**0.0014**	**0.0023**	**0.0014**	**0.0023**	**0.0015**

In brief :

- The powered flowhood has a maximum difference of 17% at calibration (supply without ATD compared to rig measurement). The result does not depend on the type of ATD and flowrate probably because the compensating fan mixes air before the measuring points. According to the lab results it seems to be the more accurate solution with the long hood.
- Propellers are quite good with differences in lab from 13 to 21%. The kind of ATD and flowrate has a small impact. The straightener tested doesn't reduce the difference for these airflows but its pressure drop is high (almost double the standard unit one). The pressure drop of propellers is always lower than 2 Pa at 30 m3/h but can achieve 20 Pa around 100 m3/h (kitchen boost airflow).
- Hot wire grills hoods are highly influenced by the type of ATD as well as the type of flow prior to the ATD which can explain the differences between on site and in lab (ie the smaller the ATD pressure drop, the more the flow before can be influenced. It explains the differences between lab (stable and straight) and on-site (elbow connections)). Exhaust and supply calibration are different. Yet we can note that these devices are normally used for higher flowrates than those tested here. The hood has a

very small pressure drop and quite a large cross section which implied a low measured velocity. In addition the two units used for this study were quite old.

3.3 Tests in CETIAT as for PROMEVENT study

To compare our results with the PROMEVENT study we have finally tested the anemometers exactly in the same conditions as in the original study.

Tests are made at 30 m3/h in supply condition on CETIAT test rig with 3 ATDs

Supply ATD with central cone	Orientable flow ATD	Fixed grill
		

Figure 6 - ATDs tested in CETIAT

A prior test is made without ATD in order to obtain the difference between the measurement with and without ATD. Only the small hoods, more adapted, have been tested in this part of the study.

Table 5 – average airflow difference for each couple ATD / anemometer

	Supply ATD with central cone	**Orientable flow ATD (lateral flow)**	**Fixed grill**
Propellers			
WOHLER	0%	17%	2%
TESTO (without straightener)	6%	/	/
TESTO (with straightener)	1%	/	/
Hot wire grills			
SWEMA	4%	13%	-1%
KIMO 1	5%	-18%	-5%
KIMO 2	5%	-19%	-2%

These tests confirm that all anemometers are sensible to the ATD with one direction lateral flow.

4 CONCLUSIONS

For supply small airflow rate measurements, the characteristic of the flow induced by the ATD as well as conditions prior in the duct (elbow, connection accessories…) have an influence on the uncertainty of measurement. One direction lateral flow is always the most difficult flow to measure but all flows can be sensible.
The average uncertainty for those measurements is around 15-20%.

PROMEVENT study had previously shown the impossibility to use one central hot wire hood for measuring supply airflow rate. These additional tests show that :

- Hot wire grills can be used but are sensible to the flow conditions as they are more adapted to higher commercial airflows
- Propellers are efficient and, with the small airflows of residential, the result is not influenced by their pressure drop. The flow straightner gives more homogeneous values but is not useful in all cases.
- Hood with compensating fan are accurate and homogeneous. There is no inluence of the pressure drop and the fan mix air before measurement which reduce the influence of the flow direction.

Tests made in lab and the dispersion on results with and without ATD shows that applying a unique correction of calibration is not efficient to reduce uncertainty. By noting differences when calibrating at exhaust vs supply, we can expect an higher influence of the flow conditions. Yet we concur to PROMEVENT conditions and consider that the respect of an EMT when selecting the unit is enough.

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